20ZTTO"96059660

Fig. 1
Prior Art

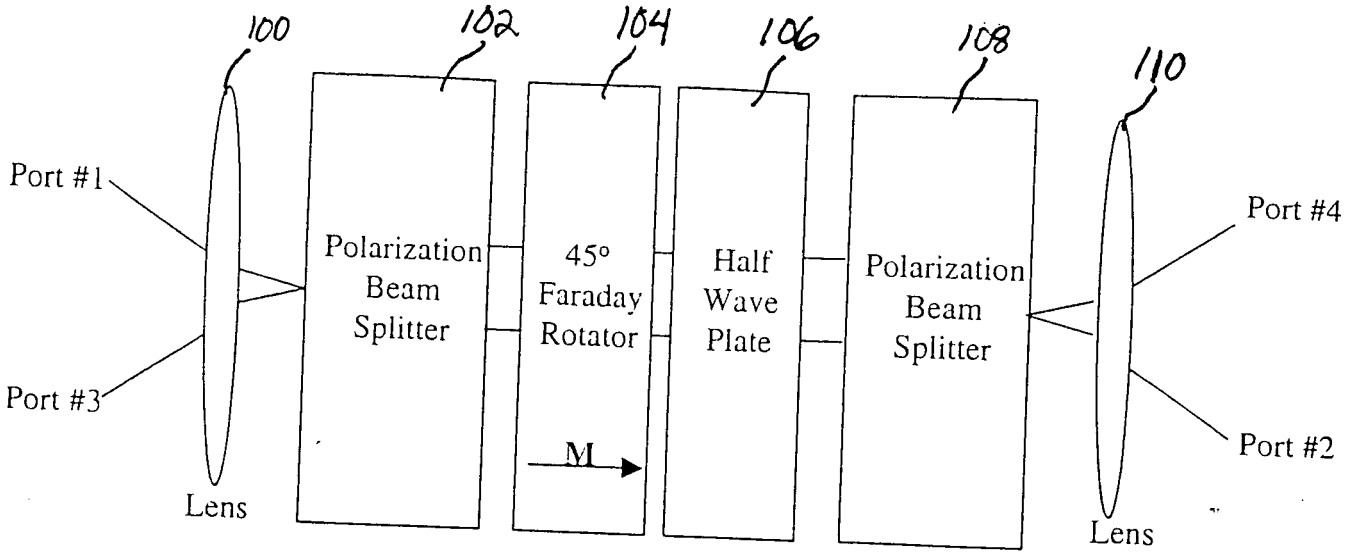
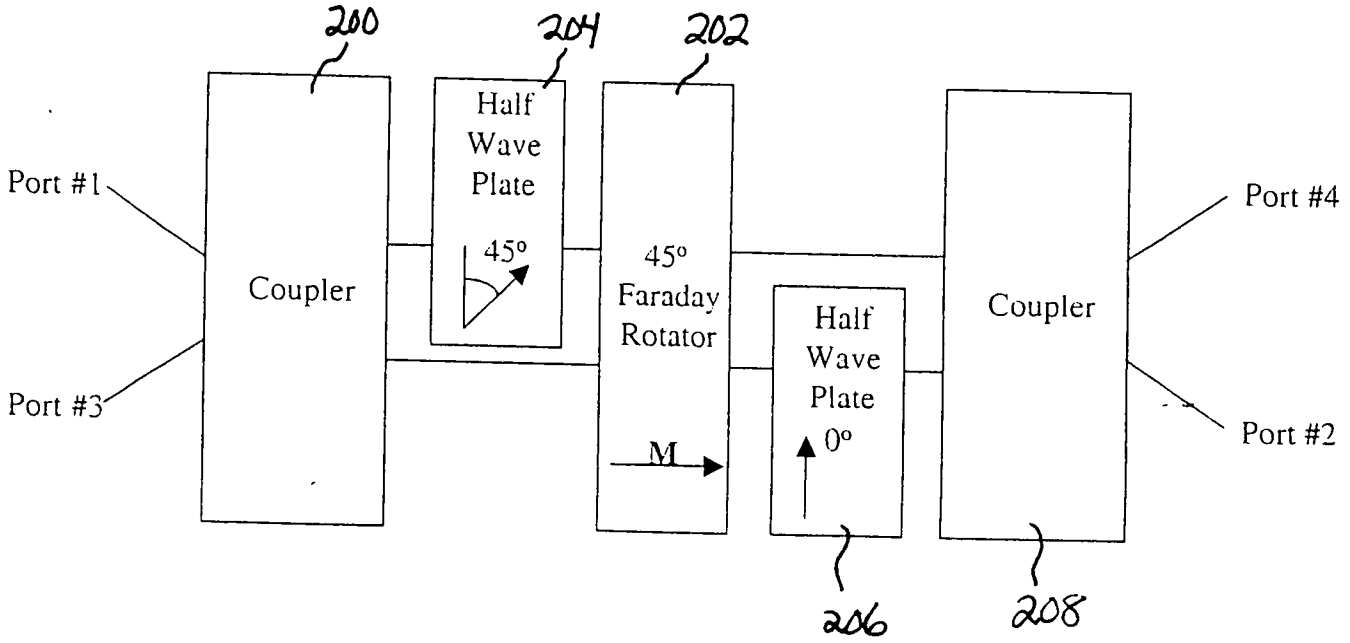


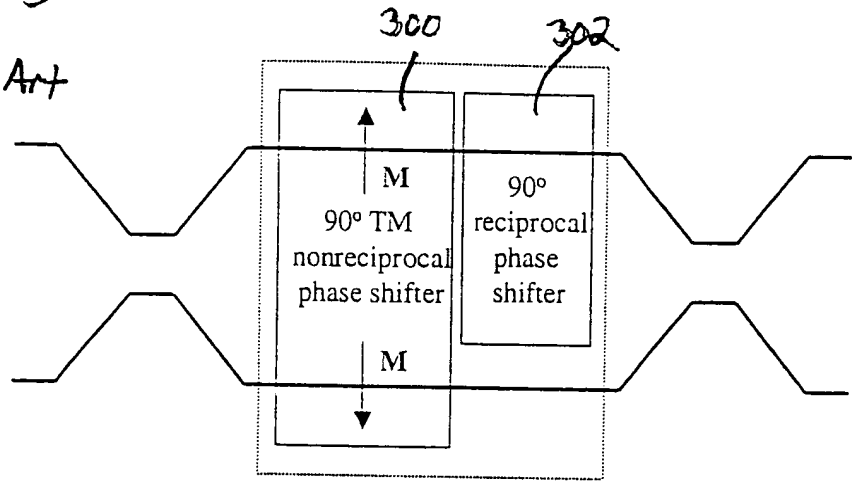
Fig. 2
Prior Art



20170095950

Fig. 3

Prior Art



Nonreciprocal phase shifter

Fig. 4A

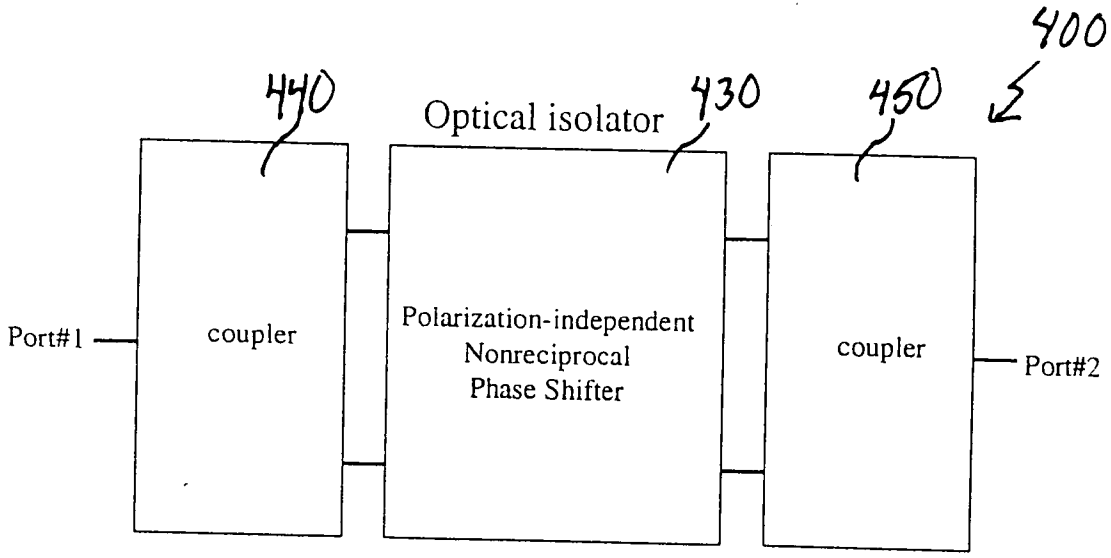

400
440
Optical isolator
430
450
Port#1
coupler
Polarization-independent
Nonreciprocal
Phase Shifter
coupler
Port#2

Fig. 4B

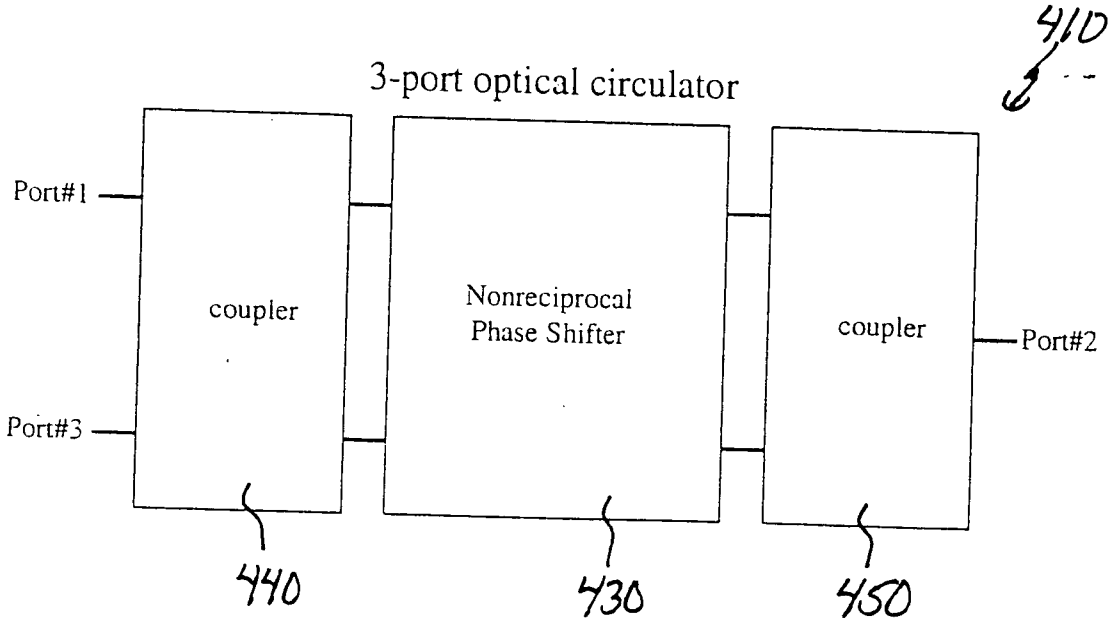

410
3-port optical circulator
Port#1
Port#3
coupler
Nonreciprocal
Phase Shifter
coupler
Port#2
440
430
450

Fig. 4C

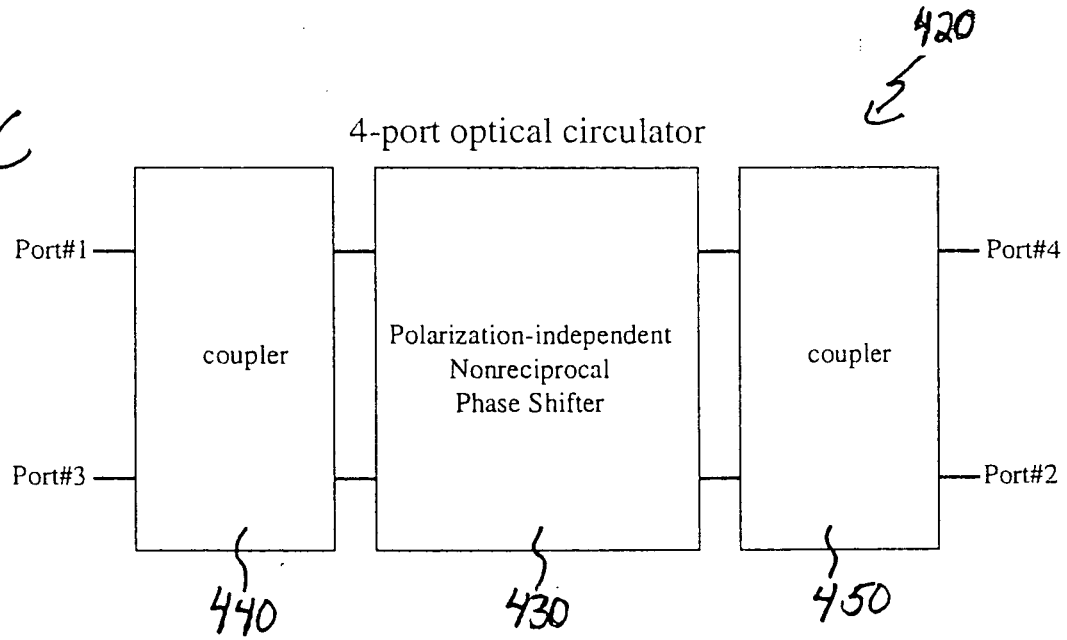

420
4-port optical circulator
Port#1
Port#3
coupler
Polarization-independent
Nonreciprocal
Phase Shifter
coupler
Port#4
Port#2
440
430
450

Fig. 5A

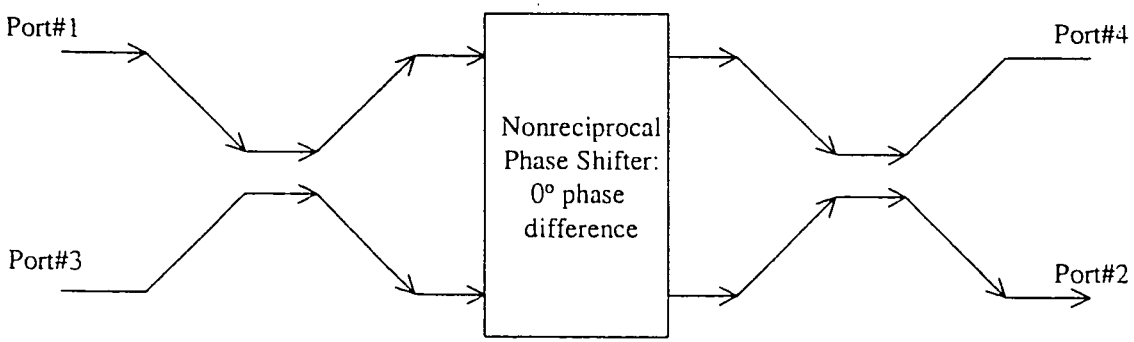

Port#1
Port#3
Nonreciprocal Phase Shifter: 0° phase difference
Port#4
Port#2

Fig. 5B

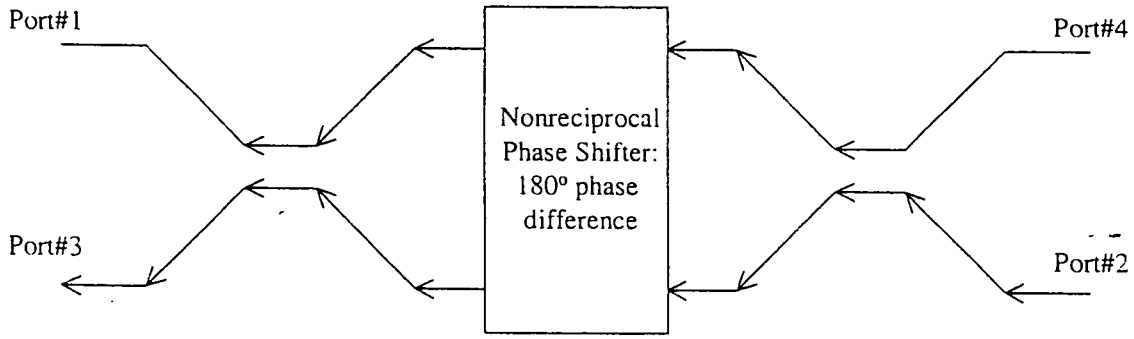

Port#1
Port#3
Nonreciprocal Phase Shifter: 180° phase difference
Port#4
Port#2

Fig. 6A

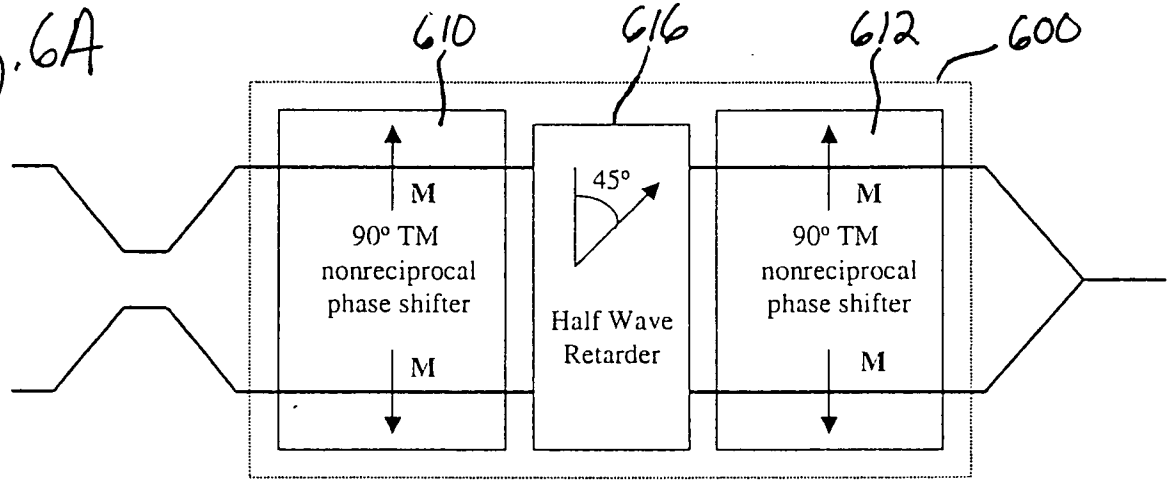

610
616
612
600
M
90° TM
nonreciprocal
phase shifter
M
45°
Half Wave
Retarder
M
90° TM
nonreciprocal
phase shifter
M

Fig. 6B

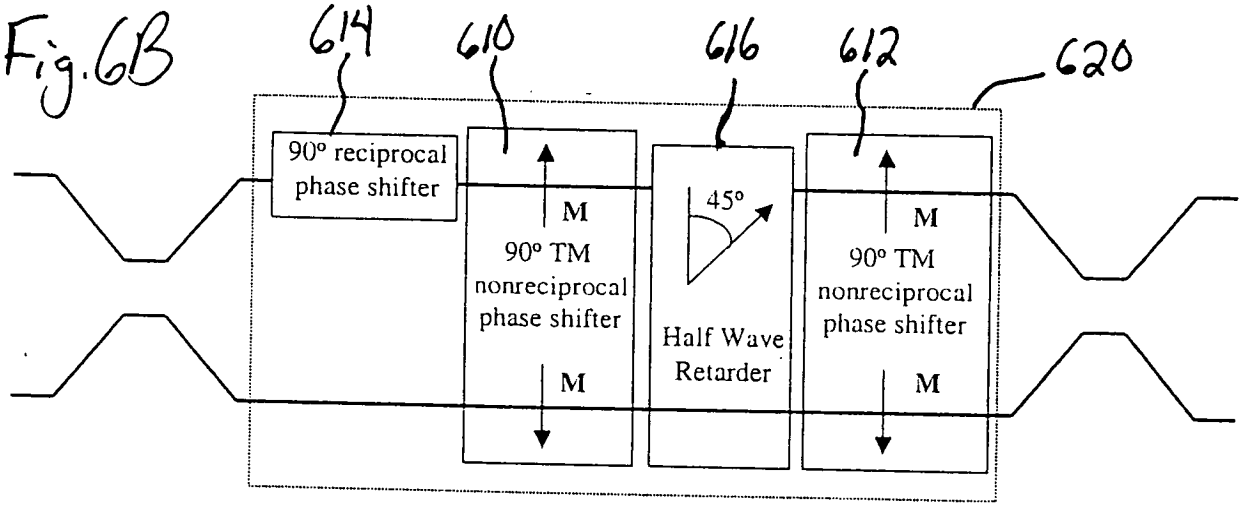

614
610
616
612
620
90° reciprocal phase shifter
M
90° TM nonreciprocal phase shifter
M
45°
Half Wave Retarder
M
90° TM nonreciprocal phase shifter
M

Fig. 6C

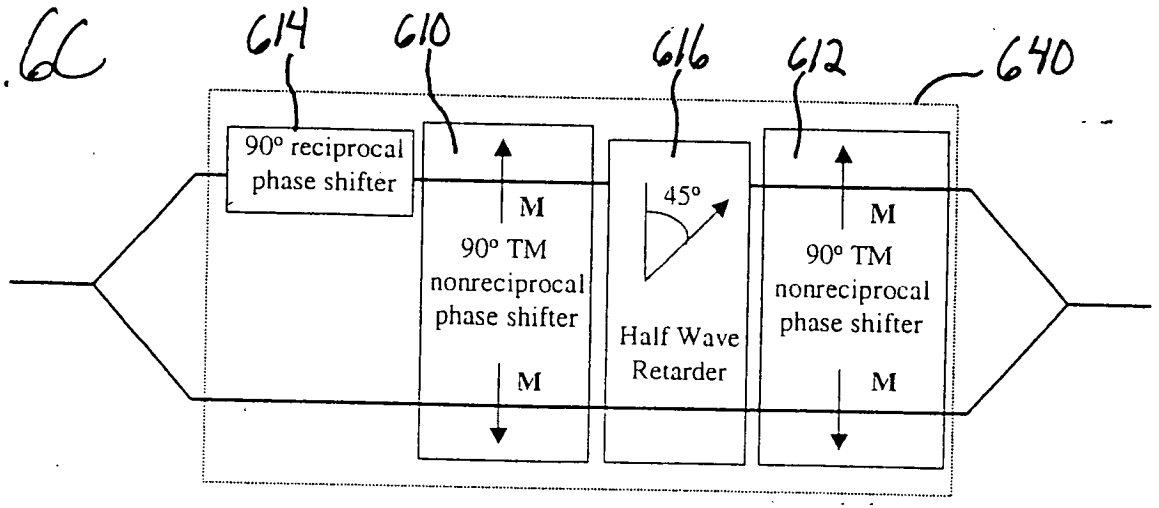
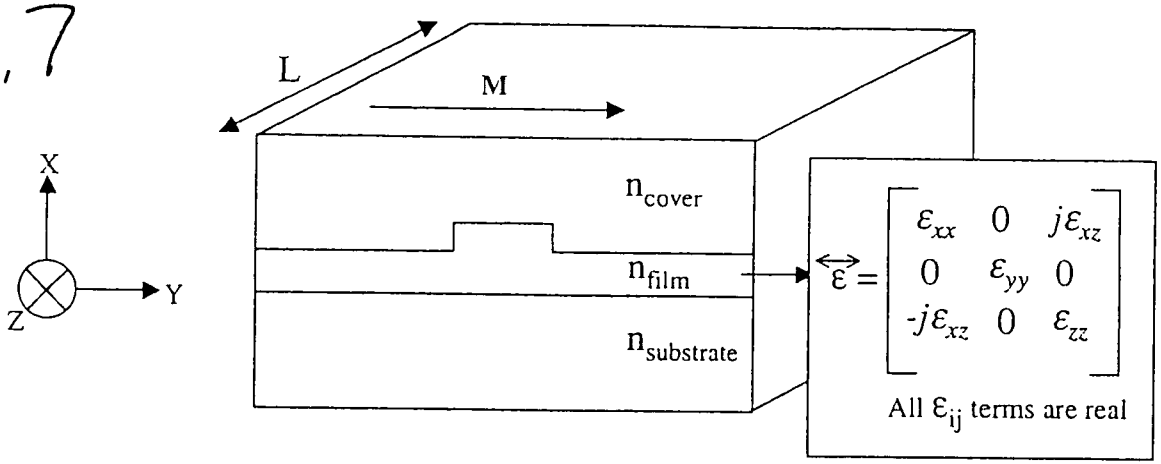

614
610
616
612
640
90° reciprocal phase shifter
M
90° TM nonreciprocal phase shifter
M
45°
Half Wave Retarder
M
90° TM nonreciprocal phase shifter
M

Fig. 7



$$\delta\beta = 2\Delta\beta = j\frac{2\omega\varepsilon_o}{N}\iint E_x^{*}\varepsilon_{xz}E_z\,dxdy$$

E_x, E_z: electric field components
ω: optical frequency
ε_o: dielectric constant in free space
N: power normalization factor

Choose: $\delta\beta \cdot L = 90^{\circ}$

Fig. 8

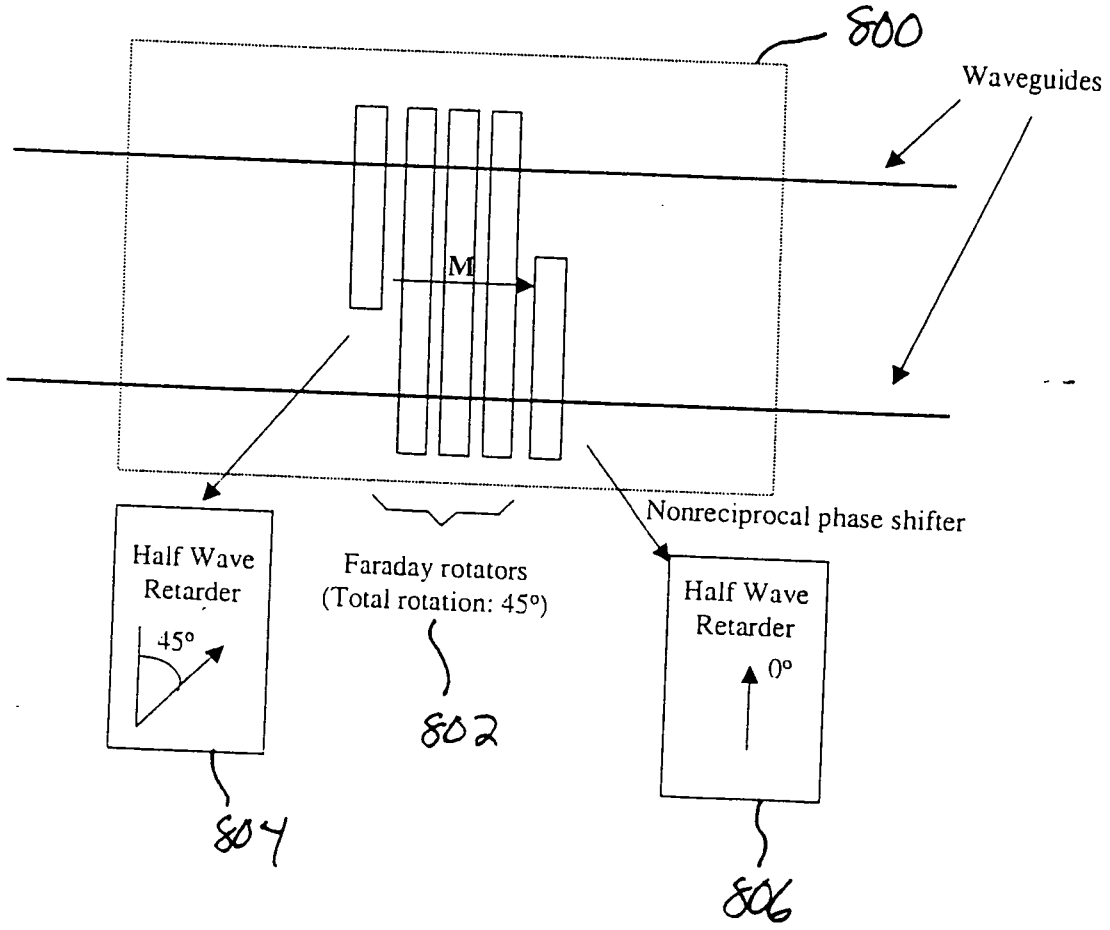

800
Waveguides
M
Nonreciprocal phase shifter
Half Wave Retarder
45°
Faraday rotators
(Total rotation: 45°)
802
Half Wave Retarder
0°
804
806

Fig. 9

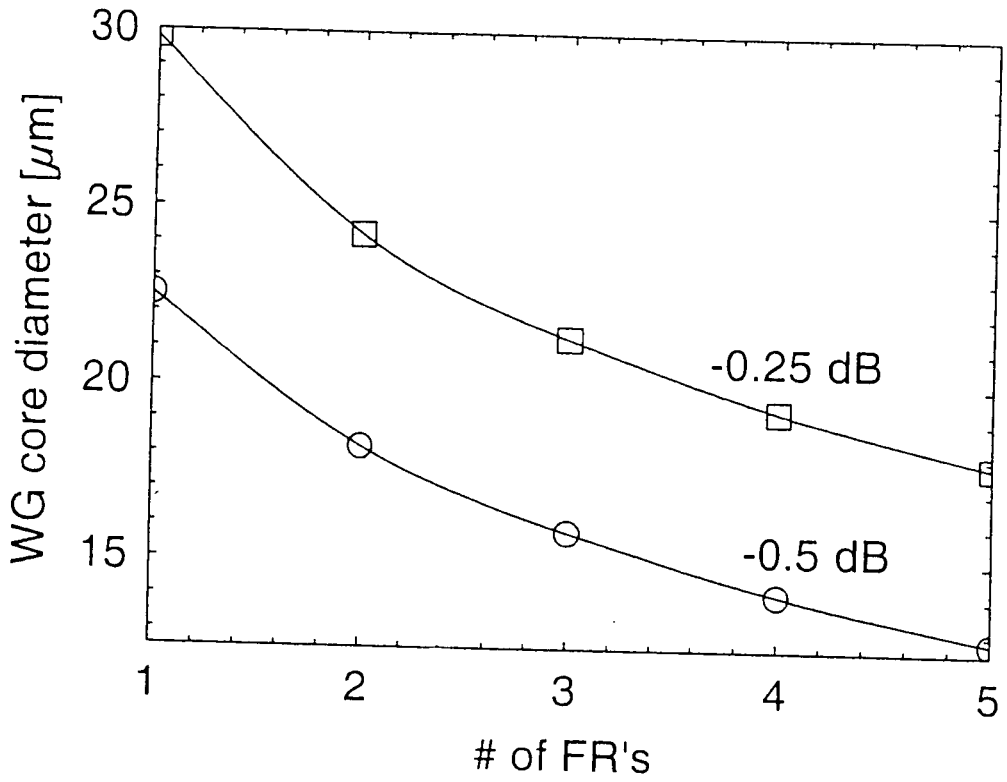


Fig. 10

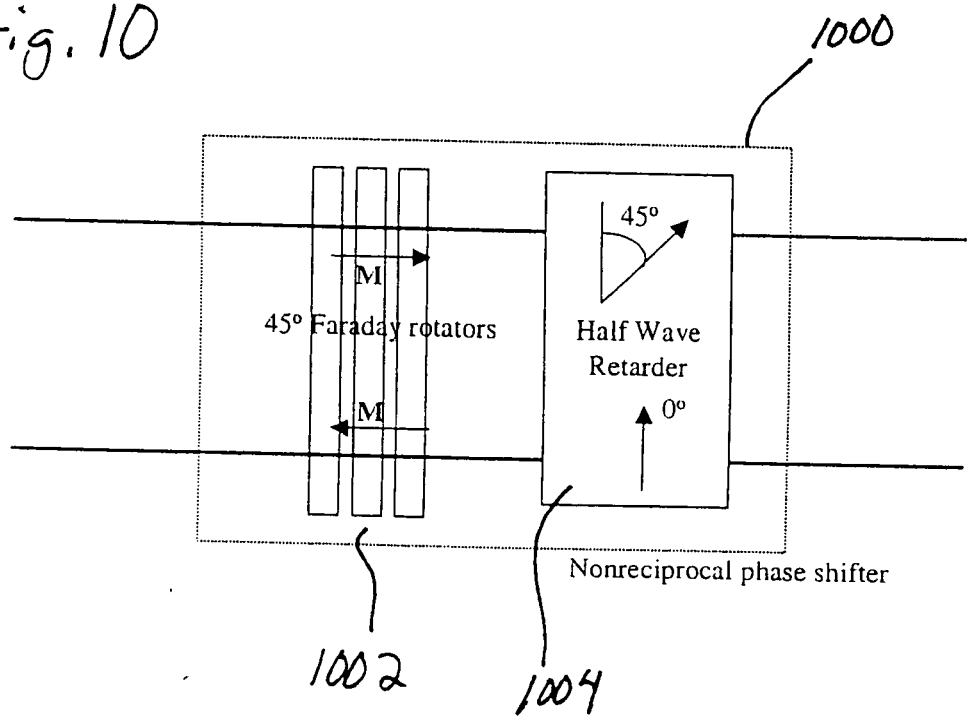

1000
45°
M
45° Faraday rotators
M
Half Wave
Retarder
0°
Nonreciprocal phase shifter
1002
1004

Fig. 11A

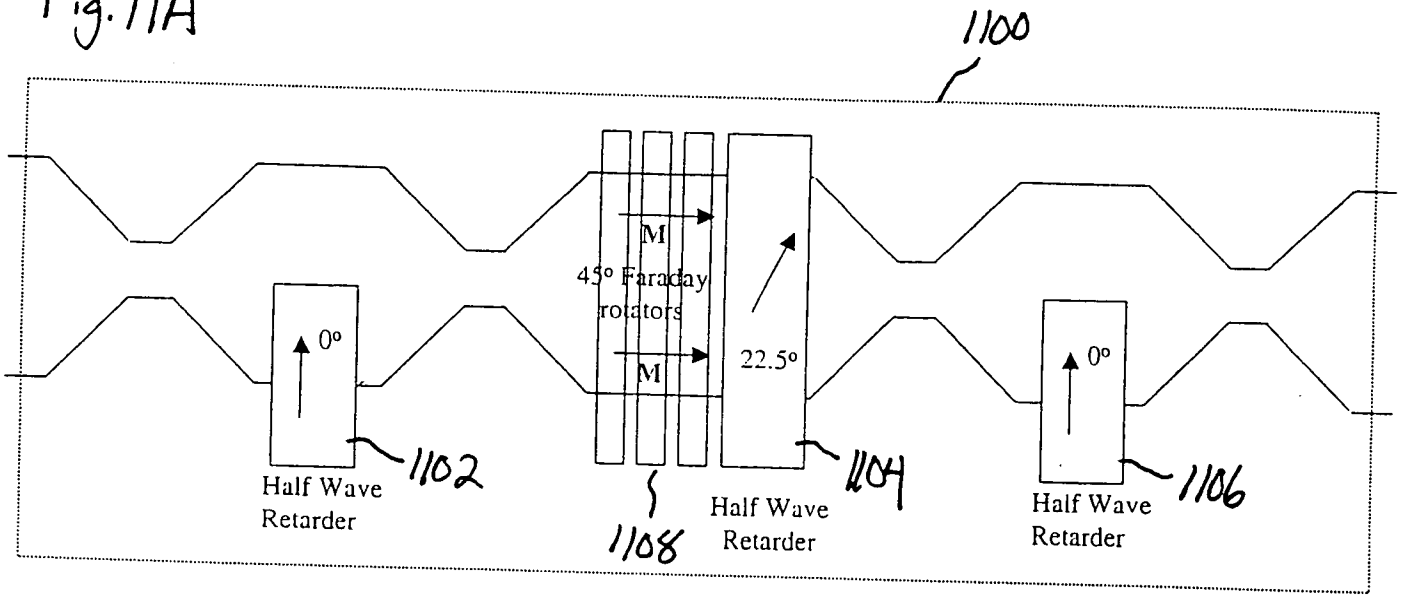

1100
0°
Half Wave
Retarder
1102
M
45° Faraday
rotators
M
1108
22.5°
Half Wave
Retarder
1104
0°
Half Wave
Retarder
1106

Fig. 11B

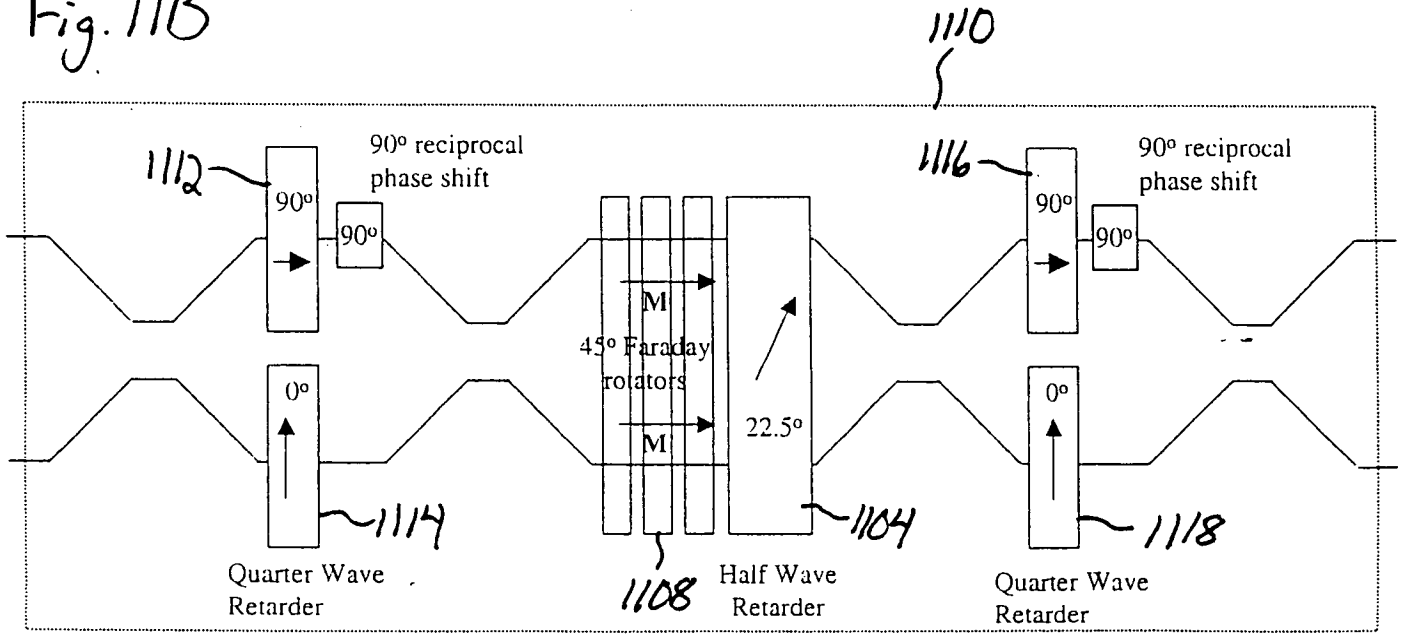

1110
1112
90° reciprocal phase shift
90°
90°
1116
90° reciprocal phase shift
90°
90°
M
45° Faraday rotators
M
22.5°
0°
0°
1114
1104
1118
Quarter Wave Retarder
1108
Half Wave Retarder
Quarter Wave Retarder

Fig. 12A

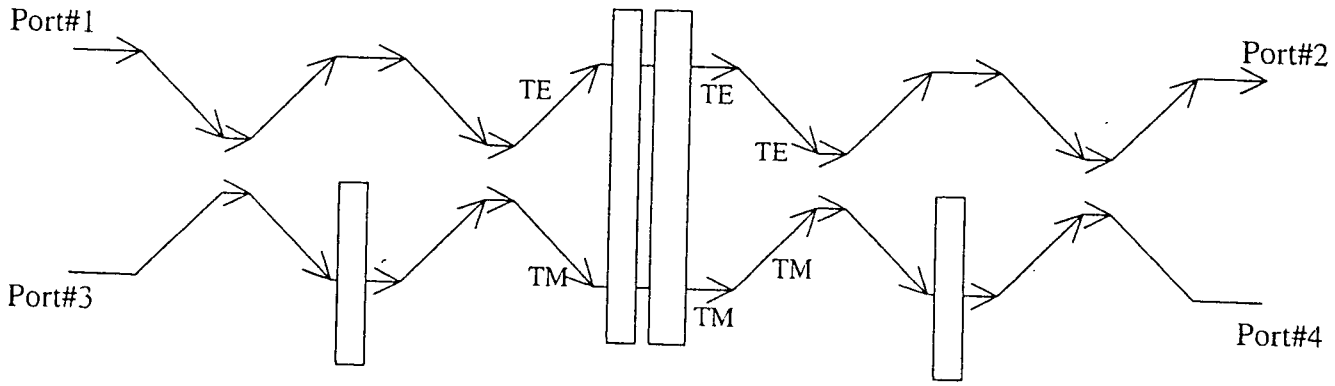
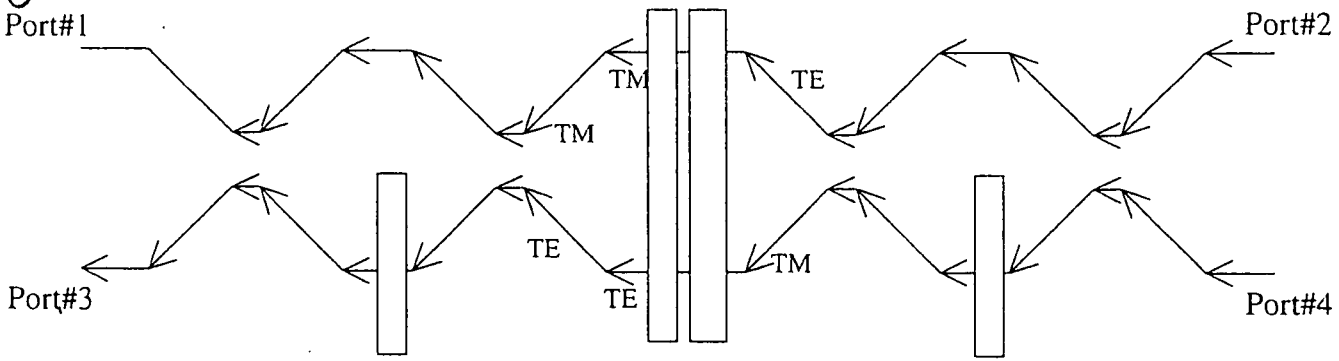



Fig. 12B